09/869859
#4 Sub Spec.

JC05 Rec'd PCT/PTO 0 6 JUL 2001

M. Brunson 9/25/01

PATENT
0787-0117P

IN THE U.S. PATENT AND TRADEMARK OFFICE

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| Applicant: | STREET, Graham Stewart Brandon | | |
| Int'l. Appl. No.: | PCT/GB00/00006 | | |
| Appl. No.: | New | Group: | |
| Filed: | July 6, 2001 | Examiner: | |
| For: | METHOD AND APPARATUS FOR CONTROL OF VIEWING ZONES IN THREE-DIMENSIONAL IMAGES | | |

LETTER

**BOX PATENT APPLICATION**
Assistant Commissioner for Patents
Washington, D.C. 20231

July 6, 2001

Sir:

The PTO is requested to use the amended sheets attached hereto (which correspond to Article 34 amendments) during prosecution of the above-identified national phase PCT application.

Respectfully submitted,

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Dated 26 January 2000

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*(The Patent Office will fill in this part)*

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STREET, GRAHAM STEWART BRANDON
IMPSTONE HOUSE, PAMBER ROAD,
SILCHESTER, READING, BERKSHIRE
RG7 2NU

Patents ADP number *(if you know it)*

7338060001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

METHOD AND APPARATUS FOR CONTROL OF VIEWING ZONES

5. Name of your agent *(if you have one)*

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IMPSTONE HOUSE, PAMBER ROAD
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Signature [signature] Date 6th January 199[illegible]

12. Name and daytime telephone number of person to contact in the United Kingdom DR G.S.B. STREET 0118 98124[illegible]

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# METHOD AND APPARATUS FOR CONTROL OF VIEWING ZONES

This invention is concerned with the field of three-dimensional imaging and particularly with the control of the position in space of the viewing zones required for an observer to view a three-dimensional image without the use of special spectacles.

## BACKGROUND

International Patent Application PCT/GB94/00405 (Street) describes apparatus in which two two-dimensional perspective images, provided by conventional liquid crystal display (LCD) panels, are combined with the aid of a semi-transparent mirror, so that each eye of the observer sees a different perspective but in the same location. This causes the brain to fuse these perspectives into one three-dimensional image. The principal purpose of the aforementioned invention is to avoid the need for the observer to wear special spectacles. International Patent Application PCT/GB96/03014 (Street) apparatus is described which provides, simultaneously, both right and left eye images from a single LCD.

In certain embodiments of both of the aforementioned inventions, the position of the viewing zone for each of the respective eyes of the observer is controlled by the precise relative positioning of two complementary optical components. The first of these comprises a regular array of juxtaposed cylindrical lens elements, or lenticles, and is commonly referred to as a lenticular screen. The second and complementary component comprises an array of light blocking regions on a transparent substrate. These blocking regions may take the form of long strips, as in PCT/GB94/00405, or they may be arranged in a chequered fashion, as in PCT/GB96/03014. By providing both the lenticular screen and the blocking pattern, referred to hereinafter as a barrier screen, with a vertically tapered structure and controlling the relative position of one with respect to the other, the lateral position of a viewing zone and its distance from the apparatus may be controlled. Such control is required at right angles to the long axes of the lenticles for horizontal displacement of the zone and along the axis of the central lenticle (vertically) for a relative change in local scale between the lenticular and barrier screens. This change of local scale gives rise to a change in the convergence of light leaving the apparatus from adjacent lenticles and, thus, adjusts the point of convergence and the distance of the viewing zone from the apparatus.

The required accuracy in the positioning of the lenticular screen, relative to its corresponding barrier screen, is high, as the optical magnification of the pattern of

the barrier screen, which gives rise to the viewing zones, may be as high as 300 : 1. Typically, relative and rapid positioning to an accuracy of a few microns is desirable in the lateral direction, whereas the orthogonal positioning requirement, will be less demanding. If a conventional control loop was applied to each component, each would be permitted one degree of freedom, all others being constrained to the required precision. In addition, the structural stability of the system, as a whole, would have to be high, so as to avoid changes of scale due to temperature changes or mechanical creep in the position of components.

## SUMMARY OF THE INVENTION

It is an object of the current invention to provide a system for the control of the lateral position of a lenticular screen relative to a corresponding barrier screen, to provide a stable and accurately located viewing zone, without the need for the structural stablity which would be demanded using independent control means for each of these components.

It is a further object of the invention to provide a convenient means for controlling the distance of the viewing zone from the apparatus.

It is another object of the invention to provide automatic compensation for any changes in relative scale or positioning, due to mechanical creep or thermal changes.

Thus, according to a first aspect of the invention, relative position encoding apparatus comprises a plurality of light blocking regions forming in aggregate at least one defined pattern on a first light transmitting substrate; a second substrate adjacent said first substrate and comprising at least one convergent element for collimating in a first plane light from points of said pattern; means for imaging said light substantially to respective image points, conjugate in said first plane to said pattern points and at an image plane; and image detection means positioned at said image plane for capturing a portion of the image of said pattern, whereby, in use, the position of the first substrate relative to the second substrate is determined.

Preferably the pattern on the first substrate comprises alternating and substantially parallel light blocking and transmitting stripes having a selection of widths and arranged in a uniquely defined manner so that, in use, the detection of three transitions within said pattern uniquely defines the location of said transitions.

According to another aspect of the invention, relative position control apparatus comprises at least two means for relative position encoding; means for obtaining relative

position data from each of said relative position encoding means; means for combining said data to derive the position of the first substrate relative to the second substrate in two orthogonal directions; and means for controlling the relative position of said substrates in said two orthogonal directions.

Preferably the pattern associated with the first means for relative position encoding is tilted with respect to the pattern associated with the second means for relative position encoding.

## DESCRIPTION OF PREFERRED EMBODIMENTS

The invention will now be described with reference to Figures 1 and 2 in which:-

Figure 1 shows a section through position encoding apparatus constructed in accordance with the invention, together with a diagrammatic illustration of encoded position data, derived therefrom.

Figure 2 shows how two degrees of freedom for relative positioning may be provided in accordance with the invention.

A typical arrangement for encoding the position of a lenticular screen relative to a barrier screen is shown in Figure 1. A lenticular screen 1 is positioned in front of a barrier screen 2. A pattern of transmitting regions and light blocking regions is shown as respectively light and bold line segments on the front surface 3 of barrier screen 2. One of the lenticular screen's lenses 4 is isolated from its neighbours by a narrow aperture in plate 5. Lenticle 4 collimates light from points on surface 3, to pass through the aperture in plate 5. A lens 6 reimages this light to form a magnified image of part of the pattern of surface 3 on a CCD array 7. If the whole of the pattern on surface 3 was imaged simultaneously onto the CCD's surface without any distortion, then this would appear as the signal shown schematically as waveform 8. In practice this is not possible nor necessary. Light transmitting gaps form image components such as 9 and 10. A blocking region creates a dark space 11. The relative dimensions of and order in which the light and dark regions are positioned uniquely defines which portion of the pattern is captured on the CCD. In fact, only three transitions are required for the particular pattern illustrated, in which three intrinsic widths are used. As the barrier screen is moved laterally 12 with respect to the lenticular lens 4, the pattern shifts on the CCD, and different groupings of transitions may be used to determine the relative lateral position of the barrier screen 2 with respect to the lenticular screen 1. More precisely, the relative position of the pattern on the barrier screen 3 is determined relative to the axis of the lenticular element 4. Typically a conventional diffuse light source 13 is positioned behind the barrier screen 2.

Figure 2 illustrates how the use of two patterns on the barrier screen may be used to determine the position of the latter relative to the lenticular screen in front of it in two orthogonal directions. For the sake of clarity, the two patterns 20 and 21 are shown close together and at considerable magnification. In pfactice, a considerable gap would be typical, with one pattern on the left hand side of the barrier screen and the other on the right hand side. Two apertures 22 and 23 are shown schematically. For the sake of clarity the lenticular screen is not included. Also illustrated is a deliberate taper between the two patterns 20 and 21. As the barrier screen is moved up and down relative to the apertures, different portions of the pattern will become central to the field of view of the corresponding CCD (as provided in Figure 1 and not shown in Figure 2). When the lenticular screen and the barrier screen have an intrinsically tapered structure, as employed in the embodiments of the aforementioned PCT/GB94/00405 and PCT/GB96/03014, it is the up and down relative motion which controls the convergence of the light transmitted through the lenticular structure and thus the distance of the resulting viewing zone or zones. By employing oppositely tapered patterns as illustrated, the change in relative position derived from each CCD is opposed when the relative motion is vertical and has the same sign when the motion is lateral. Thus, by averaging the resulting relative motions, an accurate lateral position is derived and, by establishing the difference in the two realtive positions detected, a term proportional to the relative vertical movement is obtained.

# Fig.-1-

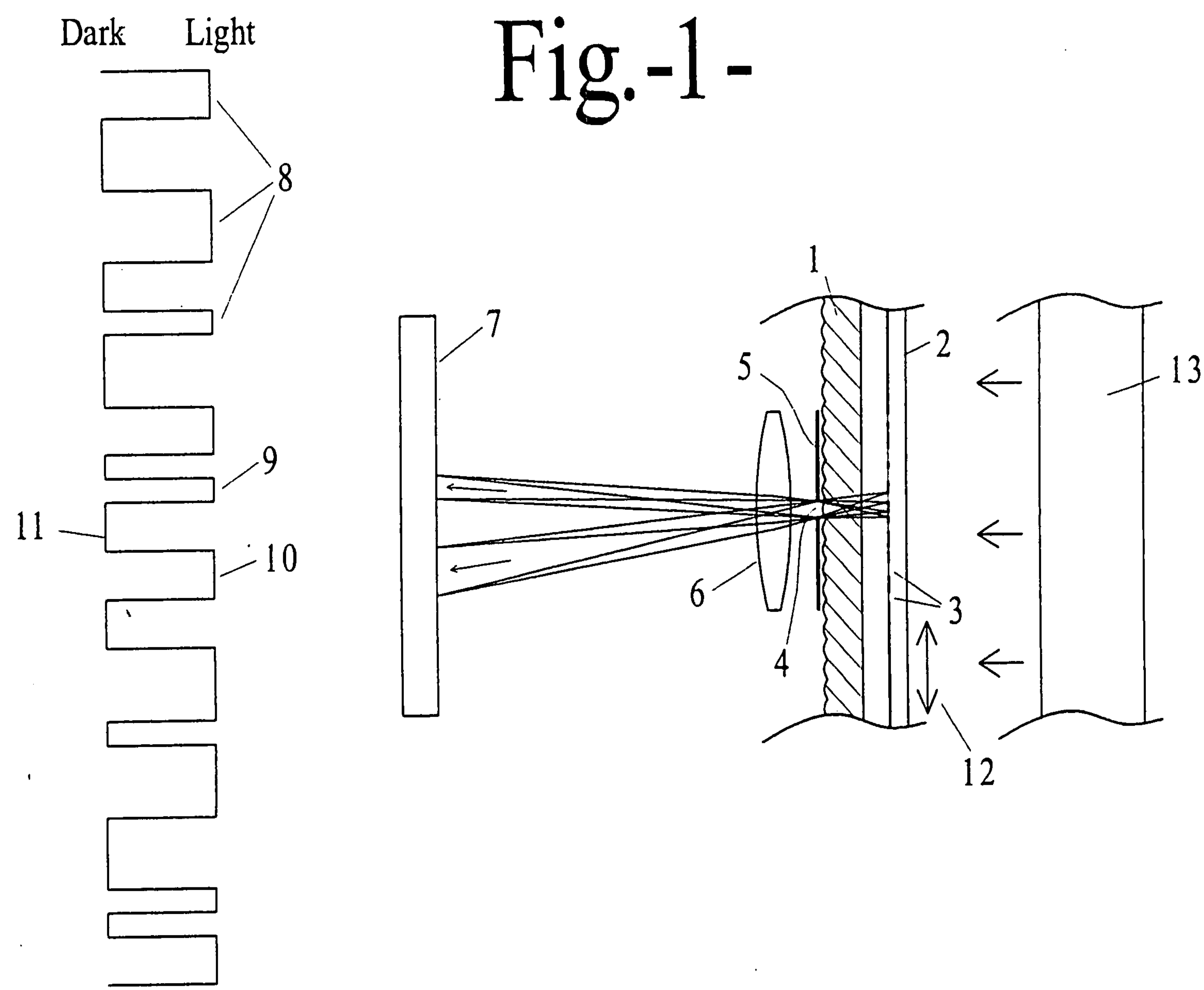

Fig.-2-